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AUTHOR	Dougherty, Barbara; Young, Donald B.
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ABSTRACT

States, school districts, and individual schools have created standards that indicate what content teachers should teach and students should learn. This document suggests that in order to have substantive effect in mathematics and science classrooms, other components must be addressed and linked to the content standards which include establishing criteria for selecting programs or materials, building a common vision for instruction, prioritizing funds, setting up appropriate teacher professional development exercises, constructing student assessments aligned with the standards, and articulating policies about resources. This briefing paper describes program and system standards and shares implications for their use. Contains 11 references. (ASK)

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Aligning Content, Program, and System Standards in Mathematics and Science Classrooms

By Barbara Dougherty and Donald B. Young*

States, school districts, and individual schools have created standards that indicate what content teachers should teach and students should learn. While it is important for these standards to be identified, they are only a beginning. Their identification alone, without consideration of other factors, will not have an effect on classroom practices.

To have substantive effect in mathematics and science classrooms, other components must be addressed and linked to the content standards. These components include, but are not limited to, establishing criteria for selecting programs or materials, building a common vision about instruction, prioritizing funds, setting up appropriate teacher professional development experiences, constructing student assessments aligned with the standards, and articulating policies about resources.

The National Research Council (NRC, 1996) and the National Council of Teachers of Mathematics (NCTM, 1991) have recommended program and system standards to address issues surrounding the implementation of content standards. Program and system standards give guidance to states, districts, and schools as they prepare to put standards-based mathematics and science in their classrooms.

This briefing paper describes program and system standards and gives implications for their use.

*This briefing paper is the result of a collaboration between the Regional Educational Laboratory (REL) and the Mathematics and Science Regional Consortium at Pacific Resources for Education and Learning (PREL). Dr. Barbara Dougherty is a Senior Program Specialist at PREL. Dr. Donald B.Young is Associate Director of the Curriculum Research and Development Group (CRDG), University of Hawai'i-Mānoa.

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Program and System Standards

The following table presents program standards and their aligned system standards.

Program Standard	System Standard
*All elements of a K-12 program must be consistent with standards and developed within and across grade levels to meet a clearly stated set of goals.	Policies must be congruent with program teaching, professional development, assessment, and content standards, while allowing for adaptation to local circumstances.
The program of study for all students should be developmentally appropriate, interesting, and relevant to students' lives; should emphasize student understanding through inquiry or problem solving; and should be connected with other school subjects.	Polices should be coordinated within and across agencies, institutions, and organizations.
The mathematics and science programs should be coordinated with each other to enhance student understanding of mathematics and science.	Policies need to be sustained over a sufficient period of time in order to provide the continuity necessary to bring about the changes required by the standards.
The K-12 program must give students access to appropriate and sufficient resources, including quality teachers, time, materials and equipment, adequate and safe space, and interaction with the community.	Policies must be supported with adequate resources.
All students in the K–12 program must have equitable access to opportunities to achieve the mathematics and science standards.	Mathematics and science education policies must be equitable.
Schools must work as communities that encourage, support, and sustain teachers as they implement effective mathematics and science programs.	All policies must be reviewed for possible unintended effects on classroom practices. Responsible individuals must take the opportunity afforded by the standards-based reform movement to achieve the new vision for mathematics and science education.

(NRC, 1996)

Program standards represent a framework of criteria by which to assess the quality of curricular and instructional resources, including student and teacher materials, associated instructional practices, and assessment techniques. Each program standard addresses a component linked to the successful

implementation of content standards. These components form a comprehensive and cohesive picture of mathematics and science content, teaching, and assessment.

System standards focus on policy development and implementation in relation to content standards. System standards reflect the importance of coordinating the efforts of agencies involved in the educational system. The coordination efforts work in concert with the program standards so that there are no contradictions and/or barriers when implementing content standards.

A description of program and system standards and their implications follows.

Program Standards

Since program standards focus on curriculum, instruction, and assessment, they speak directly to the implementation of student content standards. Without appropriate programs that are linked specifically to content standards, what we teach and how we teach it (asking students to answer a set of questions at the end of a chapter, for example) may remain, in many classrooms, as it has always been. In this scenario, students may be asked to participate in activities that are loosely connected, if at all, to a larger goal or concept.

Implementing Student Content Standards. Science and mathematics programs must first begin with clearly stated expectations that define what students are expected to learn in relation to the content standards. Some entities, states, or schools call these expectations *benchmarks*. Benchmarks provide direction for moving closer to the vision created by the standards; they establish a point of reference for measuring or judging quality (American Association for the Advancement of Science, 1993). Thus, benchmarks give teachers direction in designing their instructional approaches to teaching subject content that is specific to their grade level or grade cluster.

Content standards are usually written in general terms and for grade clusters rather than for a specific grade, unlike behavioral or instructional objectives. Teachers often have difficulty deciding what they are supposed to teach in their grade, given the generality of the standards. Benchmarks provide stronger directions for teachers and help build cohesiveness and consistency between and across grade levels.

While there are many ways of teaching mathematics and science, there should be a consistent instructional philosophy among teachers, administrators, and community members about what constitutes standards-based teaching. Time should be spent creating components of instruction that describe what a visiting observer in a standards-based classroom would see.

This vision of standards-based teaching should include possible classroom activities and methods of instruction. What is the teacher in a standards-based mathematics and science classroom doing—lecturing to the whole class or separating students into small groups to cooperatively solve a problem using graphs and charts? Are students gathering information from a variety of sources, including elders in the community? Answers to these and other questions help the teacher to focus on learning activities that actively engage students in the classroom. While engaged in lesson planning, the teacher should focus clearly on what the students will be doing while involved in the learning experience, not on what the teacher will do when presenting the lesson.

The process of developing a classroom vision gives teachers and administrators opportunities to articulate detailed descriptions of standards-based mathematics and science instruction. By focusing

on both teachers ***and*** students, the classroom picture becomes clearer and brings life to the content standards document.

A document containing new content standards should not be a status quo document (Begg, 1994). Instead, it should introduce new ideas that many teachers and students have never experienced, observed, or possibly even thought about. Asking teachers to implement instructional strategies that they themselves have never experienced as a learner is a tremendous leap for many. This process implies that professional development is necessary in order for teachers to make the transition to a standards-based system.

Assessment practices for mathematics and science programs must be carefully selected so that they represent important ideas that students should be learning, as stated by the benchmarks or standards. If teachers change what they teach and the way they teach it, then they must also change the way they assess. How a content standard or benchmark expresses content knowledge indicates how it should be assessed. For example, if the benchmark says that students must "explain the solution to a non-routine problem," then they must be given a non-routine problem (one that is not solved using an arithmetic computation or algebraic manipulation) and expected to write or orally present an extended explanation. Clearly, the typical test formats of multiple choice, true/false, or short answer is not appropriate for assessing benchmarks of this type.

Assessment techniques in the classroom are not the only ones that must be aligned with the identified standards or benchmarks. Larger, external assessments such as standardized tests should also be evaluated on their appropriateness for measuring student performance of content standards.

Aligning content areas, instructional practices, and assessment techniques with the standards is an important beginning. In practice, however, the alignment in and of itself does not assist in classroom implementation. Teachers need instructional materials such as reading selections, textbooks, and resource units that embody the content standards, along with associated instruction and assessment practices. Careful consideration of materials must be made if teachers are expected to implement the content standards. Elementary teachers in particular are responsible for making these changes in ALL subject areas. The amount of time required for planning is astronomical, and thus teachers cannot be expected to create lessons from scratch every day. Good materials that fit the standards are a necessity.

When materials are assessed for alignment to the content standards, those responsible for selecting the materials must first be knowledgeable about the standards. That is, they must understand 1) the mathematics and science content covered in the standards and associated benchmarks, 2) the instructional practices necessary to deliver the content, and 3) the assessment techniques that will bridge what students learn with how they learn it.

When materials are selected and purchased, this sends a message that they are aligned with the content standards and related instruction and assessment practices. Since these materials will look different than ones currently being used, it is important to include professional development as the next step in the materials-selection process. That is, professional experiences for teachers must be arranged to help them learn how to use the materials.

Professional development. Once the standards are in place and the materials selected, the next phase of content-standards implementation begins. This phase focuses on the professional development that is required for teachers, administrators, and other appropriate personnel.

Funds designated for professional development must be spent wisely. Thus, it is imperative that careful planning is completed before professional development experiences begin. There are several considerations for professional development experiences.

First, a set of goals should be developed ***with*** teachers (Loucks-Horsley, Hewson, Love, & Stiles, 1998). These goals should reflect the teachers' expectations of their students and should inform the questions that curriculum coordinators or professional developers will ask, such as, What do teachers need to know and be able to do in order to teach students using these standards?

A key notion here is the concept of developing goals ***with*** teachers, not for them. If the goals (and, hence, the types of professional development) are developed at the administrative level alone, they ignore the experiences, expertise, and direct needs of the teachers.

As Fullan and Hargreaves (1996) indicate—

> Staff development is often driven not by strategies likely to improve the all-round quality and performance of schools, but by administrative and political pressures to get preferred, sometimes "faddish" innovations implemented quickly. (p. 17)

Once the goals are clear, professional developers need to see how they fit within the context of the school or district. Professional development or programs should be adapted to fit the teachers' surroundings in at least three ways (Fullan & Hargreaves, 1996). First, teaching varies from setting to setting. What is appropriate in early elementary grades might not be appropriate for intermediate or high school grades. Second, how practical are the ideas in the professional development sessions? Cooperative learning, for example, can produce problems in entities where there are traditional views of how boys and girls function in groups. Third, there are some boundaries that might inhibit implementation. For example, a class of 40 students may be typical, but the large number of students might hamper efforts to rearrange a classroom for small-group work or procure enough manipulatives for all students.

As part of the contextual considerations, planners should be aware of where students and teachers are now, in relation to the implementation of standards-based instruction. Very traditional teachers cannot be expected to become hands-on, student-centered teachers after one workshop. Neither can students who have never experienced higher-order thinking tasks be expected to become excellent problem solvers overnight. Thus, as professional development is planned, there needs to be a clear picture of how teachers and students will move from where they are to where their vision of standards-based mathematics and science teaching and learning will take them.

The type of professional development provided plays an important role in the success of content standards implementation. Each professional development model (as shown on the following chart) is geared toward specific methods of implementation: developing awareness, building knowledge, translating knowledge into practice, practice teaching, and reflecting. Since each model is implemented in different ways, it is important that the goals of professional development experiences are carefully thought out before holding the sessions. Many times, professional development sessions are scheduled and the presenter is solely responsible for planning and presenting the sessions. It would, however, be more efficient and effective if the sessions were specifically designed to match the implementation needs of the content standards.

The following table, which was taken from Loucks-Horsley, Hewson, Love, and Stiles (1998), shows 11 models and their associated methods of implementation.

Eleven Models for Professional Development *

Model	Methods of Implementation				
	Developing Awareness	Building Knowledge	Translating Knowledge into Practice	Practice Teaching	Reflecting
Immersion in Inquiry/Problem Solving	x	X			X
Curriculum Replacement		x	x	X	
Curriculum Development-Adaptation		x		X	
Workshops-Institutes	x	X	x		
Action Research		x			X
Case Discussion	x	x			X
Study Groups	x		x		X
Examining Student Work	x	x	x		X
Coaching and Mentoring		x	x	X	x
Partnerships	x	X			
Professional Networks	x	X	x		x

* X indicates primary purpose or type; x indicates secondary purpose or type.

Once the professional development sessions have been delivered, there must be time for implementation (Loucks-Horsley, Hewson, Love, & Stiles, 1998). This is a critical phase of professional development and one most often neglected. Regularly scheduled follow-up should be included as an integral part of any professional development plan, not an afterthought.

Curriculum materials are also an important part of the professional development delivery. In this case, *curriculum materials* refer to those that would be appropriate for use with students in the classroom once teacher training is completed. Professional development without the benefit of these materials relies on the assumption that teachers will be able to adapt the ideas learned during professional development activities to their students' needs, school context, and resources. In many cases, professional development focuses on instructional or assessment practices that are not consistent with existing curriculum materials, making it difficult for teachers to adapt those materials once they leave the professional development sessions and return to the reality of the classroom. Thus, existing curriculum materials need to be included in the professional development sessions, so that teachers can learn how to revise, adapt, or implement them.

As teachers implement new ideas and approaches, it is important to solicit continual feedback from them on how these new methods are working in the classroom. Caution should be exercised here, however. We often hear educators talking about how "good" something is going or how well a new idea "worked." From the start of a professional development effort, there should be well-established criteria by which to judge how well something is working. Saying that the students like it or the teacher likes it does not mean that the desired results have been attained.

As information about the implementation is collected, it can be used to revise future professional development experiences or to shape the follow-up support. Follow-up support is a necessary portion of any professional development effort. One-shot workshops, repeated over time, do not address the issues that teachers face when they return to their classrooms. They need well-thought-out follow-up that will address the context in which they teach. If, for example, they are teaching on an outer island that has only one multi-grade school, these teachers will need help in adapting the curriculum to a diverse student group, especially since teachers in this situation often do not have time for planning and do not have extended periods of time with any one group of students.

Changes in content, instruction, and assessment create the need to explicitly state the responsibilities involved in implementation. Superintendents, boards of education, curriculum coordinators/specialists, principals, and teachers must be aware of, and held accountable for, their roles in pursuing robust and substantive implementation of the standards/benchmarks and their associated instructional and assessment practices. In some cases, traditional roles of principals or other administrators may need to be changed to reflect the implementation needs of the standards.

Teachers are often sent off to training, returning to their classrooms to implement the curriculum frameworks on their own. Principals may not be aware of what the frameworks entail and might not have processes in place to assist teachers in the implementation process. Placing the responsibilities at the school level gives the teachers needed support for implementing the new curriculum. It also places accountability at the school level, rather than at the district or central office level, to promote the changes brought about by the new curriculum standards/benchmarks.

Ultimately, teachers are the key to implementing standards in mathematics and science. However, they need to be part of a support system that helps them break the isolation barriers often found in their schools. This may require bringing teachers together to discuss individual student learning needs and to reflect on their practice. Additional time must be available for them to observe other teachers and classrooms, teach with other teachers or specialists, plan with other teachers, and attend conferences or trainings.

System Standards

The classroom is one small part of the entire education system of a state or entity. An education system includes the schools, the ministry or state department of education, higher education institutions, accreditation agencies, professional organizations, and the local community. Individuals and agencies responsible for administration, finance, and teaching are the ones who create, disseminate, and implement educational policies and practices.

Combining these factors with program standards creates a systemwide process. As Kniep and Martin-Kniep (1995) indicate, there is a need for coherence in programs and in systems. In order to achieve systemic cohesiveness, it is necessary to coordinate three broad areas of schooling: 1) the curriculum that will be used; 2) the organization and delivery of learning experiences; and 3) an organizational culture that effectively supports and nurtures successful programs and practices. The first two areas are addressed through the program standards. It is the third one that deals with system-wide support for the implementation of content standards.

As McLaughlin and Talbert (1993) indicate, meeting educational goals as depicted by the entity's standards "requires a policy frame that moves beyond a 'project mentality,' and away from a 'one thing at a time' approach to reform, to consider simultaneously the policy issues central to *all three aspects of the classroom core:* content, students and teacher" (p. 19).

When implementing new curriculum frameworks in mathematics and science, it is not enough to merely give documents to schools and hope that the documents will produce higher student learning in those subject areas. Instead, we should focus on the larger systemwide picture and how the curriculum, external tests, and standards fit into it.

Changes in content standards alone are not enough. These changes should cause us to examine how strong, interconnected, and rigorous all components of the entire system are. Many teachers in the field are uncertain about how to implement content standards in the classroom. They are faced with increased expectations for students, but are not expected to fail more students or water down the intended content standards.

Given this, as well as the need to change student expectations, administrators need to focus on reframing policies to address how best to support classroom implementation. In some cases, this will require dramatic changes in existing policy, formation of new policies, deletion of some old ones, or even rethinking how budget moneys are prioritized.

Policy development. As policies are developed or changed, they must be reviewed for consistency with the existing mathematics and science content, teaching, and assessment standards. Glickman (1993) offers some guidance in reviewing policies.

1. Study existing policies, and determine which ones are actually helpful or at least will not get in the way of implementing the content standards.

2. Identify any policies that are immediate barriers to the content standard implementation. These may include assessment, graduation, or other policies.

3. Press for the development of new policies at the school, district, state, and national levels. (Glickman, 1993, p. 137)

Financial policies. Without adequate resources available to purchase instructional materials, new mathematics and science content standards might not be implemented. In many schools in the Pacific, teachers have only old textbooks that were written long before the advent of space travel. There may not even be enough books for each child. Thus, teachers must, out of necessity, fall back on lessons that they can teach from experience. Quite often, these are not lessons that match the intended standards.

Time is another financial matter. Teachers need time to plan together, discuss the meaning of the new standards, and visit each other's classrooms to observe lessons. When time is made for these activities, accountability measures must ensure the productivity of these activities.

These financial decisions are some of the most difficult to make. When funds are already in short supply, stretching them to include more activities or resources seems impossible. However, this can provide an opportunity to seriously examine priorities. Detailed budget reviews that focus on areas where money is being used, and comparison of those areas with impact on student achievement, should provide some guidance for redistributing funds.

Equity. Student learning should be viewed as the primary focus of all education. ***All*** students—not just a select group—should have equal access to learning opportunities. This idea brings up at least two concerns that require attention.

First, all students must have the opportunity to learn. In some schools, this may mean that classes should be open to all students, not just an honors class or other select groups. In general, however, the opportunity to learn is linked to teacher dependability. That is, teachers need to be on time for class and remain in their classrooms, teaching. Without effective teachers, students cannot hope to achieve.

Second, there must be equitable ways to assess both student learning and programs. External assessments (as well as classroom assessments) must be closely linked with content standards. As content standards are developed and implemented, external assessments such as standardized tests and high school entrance exams must be reviewed and adapted to reflect new student learning. For some tests, there may be a need to include open-ended questions rather than including only multiple-choice items. For all tests, the content covered by the new standards needs to be revised. In mathematics, for example, computation is frequently the only mathematics activity tested. Yet, mathematics standards might require students to "model 3D solids from isometric drawings" (Grade 6, Republic of Marshall Islands Mathematics Curriculum, 1998) or "investigate and describe the properties of pyramids" (Grade 4, Republic of Marshall Islands Mathematics Curriculum, 1998). Clearly, neither of these skills can be measured by a multiple-choice item.

Assessments are used to judge the effectiveness of a new program. As Young, Dougherty, Lai, & Matsumoto (in press) describe, it is important to include valid and reliable assessments when looking at new programs that have been implemented in the school. Many new and effective programs have been discarded, and others are kept in use even though they are ineffective. Program assessments, however, can help curriculum specialists decide whether or not all students are learning, or whether the program benefits only a few.

Implications and Recommendations

New content standards for students necessitate change in the classroom even though it can be frustrating for teachers and students to change the status quo. Often, a familiar cycle develops in the

change process: introduce something new (in this case, the standards), complete initial training, and then hope that the intended users (teachers) will put the new idea or concept into practice (Hord, Rutherford, Huling-Austin, & Hall, 1987). The actual implementation often never occurs, and the new idea falls by the wayside.

This happens for a number of reasons. Sometimes, teachers do not see a need for change because they perceive that their students are doing fine without it; others do not understand the new content; and some will remember that changes in the past have failed. Students may fight the changes; they like the predictability of the established lessons. But, in many cases, there is little advance planning towards implementing standards.

Implementing new content standards in mathematics and science requires more than producing documents. Educational systems at the classroom, school, entity, and national levels must focus on multiple facets if the implementation efforts are to be robust, substantive, and consistent. Many factors must be considered: content, materials, associated instructional and assessment practices, professional development, policies, and financial impact. All of these factors must be coordinated and aligned so that implementation of content standards is enhanced and supported rather than thwarted. Some specific recommendations are offered.

1. As content standards are being developed, determine an implementation plan that includes a timeline for purchasing materials, reviewing assessments, and delivering professional development.

2. Design a method for disseminating the standards. How will principals, teachers, students, and parents learn about them?

3. Create accountability measures for schools and classrooms so that implementation of the content standards can be monitored.

4. Develop a common vision for standards-based classrooms. Explicitly describe what teachers and students will be doing. Be detailed enough that any observer would be able to see the standards-based characteristics.

5. Share the vision with parents and community.

6. Structure professional development activities so that they move teaching and learning toward the standards vision.

7. Revise old policies or create new ones that support rather than hinder standards implementation.

8. Revisit teacher evaluation instruments in order to align them with standards-based teaching expectations.

9. Search for materials that embody the standards, then provide teachers with professional development to learn how to use them.

Specific recommendations for implementing content standards are presented in the program standards and system standards sections of this briefing paper. These recommendations promote a coor-

dination of efforts across educational departments, schools, and grades, rather than compartmentalizing the implementation to just mathematics or science. Implementation of standards requires that thorough planning be completed before content-standards documents are given out.

By taking a broader look at requirements for implementing new content standards, teachers and administrators can help students achieve higher academic levels, the ultimate goal of education.

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